

QUALLA EASTERN BAND OF CHEROKEE HOUSING AUTHORITY TRIP REPORT

Assessment of Mold and Moisture Conditions

Final Report

Date:

February 23 - 24, 2005

Prepared for:

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Office of Native American Programs

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PART I
QUALLA EASTERN BAND OF CHEROKEE HOUSING
AUTHORITY TRIP REPORT
February 23 - 24, 2005

Introduction

An investigation of mold and moisture conditions was conducted on February 23 - 24, 2005, by William Rose of the Building Research Council at the University of Illinois and Robert Nemeth of Magna Systems, Inc. Several members of the Qualla Eastern Band of Cherokee Housing Authority (QCHS) staff escorted the assessment team to eight homes and the Courthouse to inspect building conditions.

This is a summary report of activities and issues identified while on site. A detailed analysis of the findings and recommendations is found in the attached report, titled: *PartII: Qualla Eastern Band of Cherokee Housing Authority Technical Housing Assessment Report: Examining Mold and Moisture Conditions of HUD Homes on the Eastern Cherokee Reservation.*

Background Information

The Eastern Band of Cherokee Indian Reservation is located in western North Carolina. The Eastern Band of Cherokee Indians has 13,079 enrolled members of which about 9,000 tribal members reside on the reservation. Tribal members are permitted to own land and homes within the Reservation, but can sell only to other members of the Tribe. Six communities are within the Reservation: Yellowhill, Birdtown, Painttown, Snowbird, Big Cove, and Wolfstown. The Reservation contains nearly 56,688 acres scattered across five North Carolina counties: Cherokee, Graham, Jackson, Macon, and Swain.

The western North Carolina climate varies from cold to warm humid weather. The average annual maximum temperature is 68.5° F, the average annual minimum temperature is 38.9° F, and the annual mean temperature is 53.7° F. The average annual precipitation on the Reservation is 58.38 inches. The average Heating Degree Days number 4728 and the Cooling Degree Days number 631. Currently, HUD records show the Formula Current Assisted Stock (FCAS) to consist of 140 Low Rent and 684 Mutual Help homes.

Day 1: Monday, February 22, 2005

Monday was a travel day to the reservation.

Day 2: Tuesday, February 23, 2005

On Tuesday morning, the assessment team met with the QCHA staff to discuss the mold situation on the reservation and determine how to proceed with the home inspections. On-site assessments began that morning with a tour of the courthouse and two homes

before lunch. The afternoon was spent at a roundtable discussion regarding mold and construction techniques, practices, and issues.

The selection of the properties to be inspected was not random, but specifically selected by the QCHA. Visual assessments were conducted at each site and digital photographs were taken to record conditions. The inspection process involved visual assessment of both interior and exterior conditions, air flow measurements of bathroom ventilation systems, and discussion with residents when available.

Day 3: Wednesday, February 24, 2005

On Wednesday six homes were inspected.

Day 4: Thursday, February 25, 2005

Thursday was a travel day back to Illinois.

The attached *Technical Housing Assessment Report* provides a detailed analysis of findings and recommendations for the homes investigated.

MOLD TESTING

The assessment team agrees that mold inside a building should be cleaned up. Generally, identifying the species of mold growing in a residence is unnecessary. No baseline exists for acceptable or unacceptable mold concentrations in a home. This message concurs with other federal agencies and experts as documented below.

The Bemidji Area Indian Health Service Office of Environmental Health and Engineering, Environmental Health Services Section (BAIHS EHSS), *Guidelines on Assessment and Remediation of Fungi in Indoor Environments*, takes this position on testing:

Consistent with Center for Disease Control (CDC) and Environmental Protection Agency, BAIHS EHSS does not recommend testing as the first response to an indoor air quality concern. Instead, careful detailed visual inspection and recognition of moldy odors should be used to find problems needing correction. Efforts should focus on areas where there are signs of moisture or high humidity or where moisture problems are suspected. The investigation goals should be to locate indoor mold growth to determine how to correct the moisture problem and remove contamination safely and effectively.

The Adverse Human Health Effects Associated with Molds in the Indoor Environment by the American College of Occupational and Environmental Medicine, states that to successfully remediate mold and moisture conditions, the water and moisture sources must be identified and corrected.

Mold spores are present in all indoor environments and cannot be eliminated from them. Normal building materials and furnishing provide ample nutrition for many species of molds, but they can grow and amplify indoors only when there is an adequate supply of moisture. Where mold grows indoors, there is an inappropriate source of water and moisture that must be identified and corrected before remediation of the mold colonization can succeed. Mold growth in the home, school, or office environment should not be tolerated because mold physically destroys the building materials on which it grows, mold growth is unsightly and may produce offensive odors and mold is likely to sensitize and produce allergic responses in allergic individuals. Except for persons with severely impaired immune systems, indoor mold is not a source of fungal infections. Current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotoxins in home, school, or office environment.

BAIHS EHSS Guidelines on Assessment and Remediation of Fungi in Indoor Environments discusses the limitations of testing as follows:

Mold testing only provides a snap-shot estimate for a single point in time and a single location. How well the test represents other locations and times is uncertain since the amounts and types of mold in the environment are always changing. Furthermore, there is no basis for setting a baseline of acceptable or unacceptable mold concentrations. The variability can be especially large for airborne molds, with significant changes occurring over the course of hours or less. Caution must also be used in interpreting surface testing results, since mold growth or deposition may not be uniform over an area and may increase or decrease as time passes. Unless many samples are taken over a period of time and the investigator has been mindful of building operations and activities during the testing, the results might not be very representative of typical conditions; in addition, tests reflecting typical conditions may also miss evidence of problems that only occur infrequently (water leaks during rain storms).

Mold testing is often expensive. Dollars spent on unnecessary testing reduce the amount of money available for remediation and repairs. The following web sites and references provide further information on mold remediation and testing:

Indoor Air Quality

Ball State University Indoor Environment Notebook - General resource on a number of topics related to indoor air quality.

http://publish.bsu.edu/ien/archives/archive_list.htm (will open a new browser window)

Mold

EPA - Mold Remediation in Schools and Commercial Buildings

<http://www.epa.gov/iaq/molds/index.html> (will open a new browser window)

New York City Department of Health Bureau of Environmental & Occupational Disease Epidemiology - Guidelines on Assessment and Remediation of Fungi in Indoor Environments <http://www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html> (will open a new browser window)

References

Guidelines on Assessment and Remediation of Fungi in Indoor Environments, Bemidji Area Indian Health Service Office of Environmental Health and Engineering, Environmental Health Services Section

The Measurement Problem Regarding Mold, by William B. Rose, Research Architect, Building Research Council/School of Architecture, University of Illinois, Urbana-Champaign Campus, 2003.

Adverse Human Health Effects Associated with Mold in the Indoor Environment: Position Statement by Hardin, Kelman, and Saxon, American College of Occupational and Environmental Medicine, 2002.

PART II

QUALLA EASTERN BAND OF CHEROKEE HOUSING AUTHORITY

TECHNICAL HOUSING ASSESSMENT REPORT

Executive Summary

Introduction

Section 1: Methodology

Section 2: Qualla Eastern Band of Cherokee Housing Authority

Section 3: Findings

Section 4: Technical Discussion and Recommendations

Appendix A: Housing Survey Summary Site Visit Report

Appendix B: Housing Assessment Results

Executive Summary

William Rose and Robert Nemeth investigated the mold and moisture conditions at the Qualla Eastern Cherokee Reservation on February 23 - 24, 2005. Several members of the QCHA escorted the assessment team to 8 homes and the Courthouse to inspect building conditions. This Technical Assessment Report will discuss housing assessment for moisture and mold problems in the homes and also include an assessment of the Courthouse.

Four issues arose: 1) site drainage, 2) unvented gas heaters, 3) stemwall/slab construction and 4) Courthouse conditions.

Site drainage

In many homes and the Courthouse water was standing on the soil surface next to buildings. Surround the buildings with a sloped skirt of soil to prevent ponding.

The Eastern Cherokee Reservation terrain is hilly. Flat building sites are rare, so new sites are typically carved out of the hillside with balanced cut and fill, resulting in a quite steep hillside slope behind the homes.

These rules make excavated hillside sites more successful:

- Ensure the resulting excavated hillside surface is stable through study of soils in the area land, planting ground cover with strong root systems, and recalling the mudslides that occurred in areas subject to very heavy rains.
- Ensure a slope between the home and the hillside drops at least 6 inches away from the home in at least 10 feet of run.
- Begin the rainwater management by determining where the rainwater should go, normally to each side of the excavation. There may be quite a bit of water to manage so the outlet must be designed to handle large quantities.
- A valley created where the swale meets the hillside should slope to either side of the home and not be level. The valley may be soil with ground cover, a trench filled with gravel with a bottom that is sloped side to side to prevent erosion, or a French drain system. (Henry French was a writer in the 1860s on Farm Drainage,

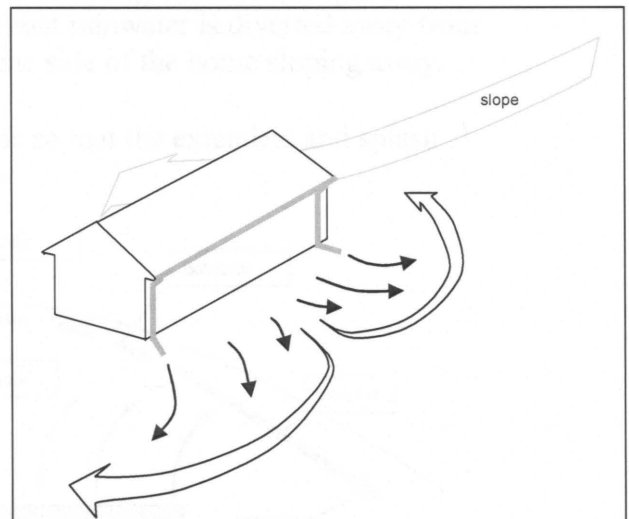
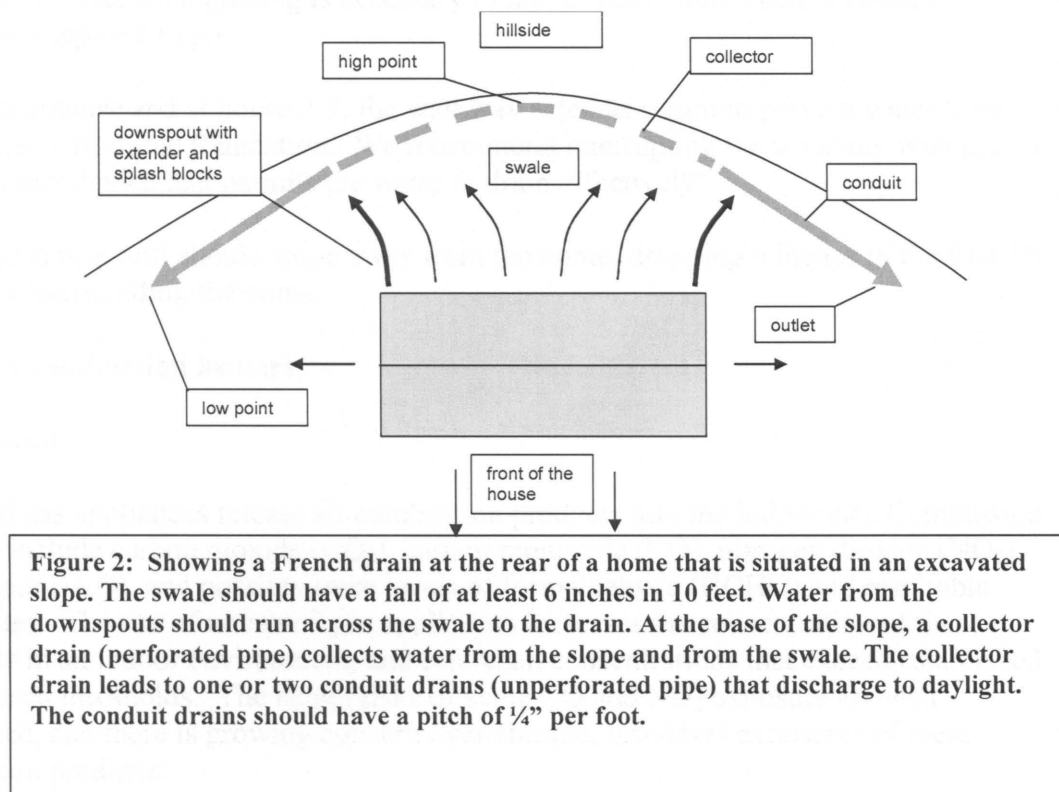


Figure 1: Showing the rear of a home situated in an excavated hillside. At the back of the home is a swale, which diverts rainwater away from the home and toward either side of the home. In this diagram, all of the arrows point downward. Note that the valley should not be flat, but should allow the rainwater to drain to either side of the home. Downspouts should deposit water to the back and side of the home.

and he developed a system using buried pipes that drain by gravity on sloped sites out to daylight) (Figures 1 & 2).

- If the home has a simple hip roof, install downspouts only on the front of the home away from the hillside.
- If the home has downspouts at the back of the home, provide downspout extenders and splash blocks to help ensure that rainwater is diverted away from the home and toward the swale or toward the side of the home sloping away.
- Consider planting bushes at the downspouts so that the extenders and splash blocks are less likely to get kicked away.



If the swale uses a French Drain, then:

- Insert perforated tile in the trench. Protect the tile against silt clogging with filter fabric, if necessary. Use fine gravel around the tile and coarser gravel near the top of the trench. Some corrugated tile will collapse when backfilled with gravel—avoid collapsed tile. Pitch the collector tile so that it is crowned at the high point and drains to either side.
- Use unperforated tile such as Schedule 40 PVC to connect the collector tile to the outlet. Install a cleanout where the collector tile meets the conduit, if deemed necessary. Ensure that the conduit tile pitches toward the outlet.

- Provide rocks or other covering at the outlet to protect against erosion of the soil above the conduit pipe at the outlet. Provide gravel where the outlet discharges water.

To provide good grading around a site, it is best to begin with a contour map showing the soil elevations. This is relatively easy to do. It involves first mapping the site with correct dimensions. Then, wood stakes can be driven into the ground in a grid, capturing at least the critical locations. A water level or a laser level can be used to translate a base elevation (1' above the highest point next to the home) and that same elevation can be marked on each stake. Measuring down from the base elevation gives the actual elevation. With that information, critical grading can take place. Otherwise, it is difficult to suggest, by eye, what grading is necessary to move water from where it resides to where it is supposed to go.

At the Courthouse and at house 2-2, the walkway acted as a dam to prevent water from flowing away from the foundation. We recommend interrupting the walkway with gravel or some other device that permits the water to drain effectively.

As a general rule, soil should slope away from the home, dropping 6 inches in the first 10 feet of soil surrounding the home.

Unvented combustion heaters

Background

Unvented gas appliances release all combustion products into the indoor air. Combustion products include carbon dioxide (CO₂), carbon monoxide (CO), nitrogen dioxide (NO₂), water vapor (H₂O), and possibly trace levels of formaldehyde (HCHO) and respirable particulates. The use of unvented gas appliances increases the concentration of these pollutants in an indoor environment, and can reach concentrations that exceed established health-based thresholds. The health risks of acute CO and NO₂ exposure are well established, and there is growing concern over chronic, low-level exposures of these combustion products.

Carbon monoxide (CO) is a toxic gas emitted from incomplete combustion of carbon-based fuels. It binds reversibly with blood hemoglobin (forming COHb), impairing the transport of oxygen to body tissues.ⁱ In the competition of carbon monoxide versus oxygen, the affinity of human hemoglobin for carbon monoxide is roughly 240 times that for oxygen.ⁱⁱ In the most severe cases, CO poisoning can lead to serious illness and even death. Unintentional nonvehicular CO poisonings result in approximately 500 deaths per year in the United States.ⁱⁱⁱ

While acute high exposures resulting in serious illness and death are noteworthy, there is a growing concern regarding low-level chronic exposure. Low-level CO exposure has been linked to impairment of neurologic and higher cognitive functions. A recent study

found significantly lower scores on seven neuropsychological tests among those exposed to low-level CO.^{iv}

The effects of chronic low-level CO exposure are difficult to recognize and treat, because individuals present non-specific symptoms (headaches, dizzy spells, malaise), and because there is a lack of awareness of the problem.^v It is likely that many more subacute CO intoxications occur than are brought to the attention of medical practitioners.^{vi} A study of 55 patients admitted to a Kentucky hospital with flu-like symptoms found that 13 (23.6%) had COHb levels above 10% (0.5% being normal).^{vii} A recent anecdote from Muncie IN indicated that during a two-day electrical power outage, the hospitals admitted 40 patients suffering from carbon monoxide poisoning, presumably from people using combustion appliances such as gas ranges that did not require electricity.

Nitrogen dioxide (NO₂) is a respiratory irritant and can cause breathing difficulty, especially for children or individuals with respiratory illnesses such as asthma. At high concentrations, a number of well-established effects have been observed in experimental studies. These include reduced resistance against respiratory infections,^{viii} lung function changes in asthmatics,^{ix} and enhanced bronchial responsiveness to allergens.^x Prolonged exposure to NO₂ has been suggested to increase the risk of respiratory infection and may be linked to the contraction of lung diseases such as emphysema.^{xi}

During combustion, all of the hydrogen in carbon-based fuels is combined with oxygen, producing water vapor. Indeed, water vapor is the most plentiful product of combustion, making up about 60% of the output of a gas fire. A 28,000 Btu/hr unvented heater will contribute 4.8 gallons of water a day to a house if operated all day long for comfort.^{xii} This is more than double the water vapor produced by a family of four from all activities. In itself, water vapor is harmless to human health. However, high wintertime humidity can cause condensation-based problems and promote moisture damage and mold contamination, leading to other health concerns. In cases where other moisture sources are present, the addition of a major new moisture source from unvented combustion can be problematic.

Given the serious health implications of combustion by-products, various state and federal agencies have established thresholds for short- and long-term exposure to CO and NO₂. Concern that pollutant concentrations would exceed these thresholds ensured that unvented gas appliances would be controversial. Several states, local jurisdictions, and model codes banned the use of the unvented products.

To date, there has been little information on the health effects of the use of unvented gas heaters in the US. Approval for the use of these devices was predicated on one report DeWerth et al. cited above. The DeWerth et al. research was funded by the Gas Research Institute and it modeled the buildup of concentrations with four hours of use, at less than extreme temperatures, and with high rates of air exchange in the home.

A recent study from Australia^{xiii} studied children in schools which originally used unvented gas heaters in the classroom. Removal of those heaters dramatically decreased the number of asthma attacks and incidents of breathing difficulty among the children.

Discussion

Unvented gas appliances have never been rated for use as the sole heat in a dwelling. They are marketed only as supplemental heating devices. Nevertheless several of the houses visited had unvented gas appliances as the sole heat source which contradicts the product directions and guidelines.

Unvented gas appliances have poor heat distribution. Bedrooms and bathrooms away from the radiant view of the heater remain unheated. Thus, they are prone to wetness and mold growth.

Heat pumps provide economical and safe heating and cooling. Occupants accustomed to radiant heating from a gas burner or a wood stove will notice that the heat from a heat pump feels different. When the heat pump is running economically, the heat delivered from the supply grilles will not feel as hot as from the radiant source, but it will feel more uniform within the room. The thermostat can be set to any comfortable temperature to compensate for the lack of a "hotspot" source of heat. Many occupants prefer a uniform heat over a point source. The distributed heat supply reduces the risk of wetness and mold growth in rooms that are distant from the heat source. The home will probably smell fresher and cleaner. It will certainly be fresher and cleaner than it would be with an unvented gas appliance.

Recommendations

1. Remove unvented combustion appliances from homes. The literature at this time simply does not support the assumption that safety and health of occupants is guaranteed when and where these devices are used.
2. Install heat pumps for heating and air conditioning.
3. Adopt a policy against the use of unvented combustion appliances in homes.

Stemwall/slab construction

All the inspected homes were of slab-on-grade construction with the concrete floor continuous all the way to the underside of the wall plate while the outside appeared as block face. This seems to indicate that the construction made use of "step" blocks (or "chair" blocks or "shoe" blocks) which are blocks that are cut to receive the cast concrete (Figure 3). The exact arrangement of block to slab was not determined during the visit.

There is no thermal break with integrated stemwall-slab construction. This has the potential for creating a cold spot at the outside corner of the floor. However, in the Middle Atlantic States this thermal bridge is preferable to having hidden pathways for termites. Keeping the block exposed at the outside, rather than insulated, is desirable.

There was evidence of water problems associated with the stemwall construction in houses 1-2 and 2-1, notably wavy sheathing and siding. The buckling in the vinyl siding occurred because of buckled sheathing beneath. Not all houses showed this condition, so a random factor appears to be at work. We may speculate that the details of the stemwall connection play a part. See Figure 10 in Section 2-1, which shows a wet spot that is level. This seems to indicate that the cores of the block are open and water is standing in the cores. (Figure 3 above shows the cores grouted solid, so they do not contain water.) This may not be too troublesome unless the concrete of the slab extends down to the level of the water, in which case, capillary action will draw large quantities of water up into the slab. Alternately, if there are holes between the slab edge and the outside face of the block, then the water in the core provides an almost limitless source of water that can evaporate up to the sill plate, keeping it wet, and helping to wet the rest of the wall.

In any case, we recommend that the wall framing be isolated from the slab, perhaps with metal sill sealer, and that any openings down to the cores be closed at the time of the pouring of the slab.

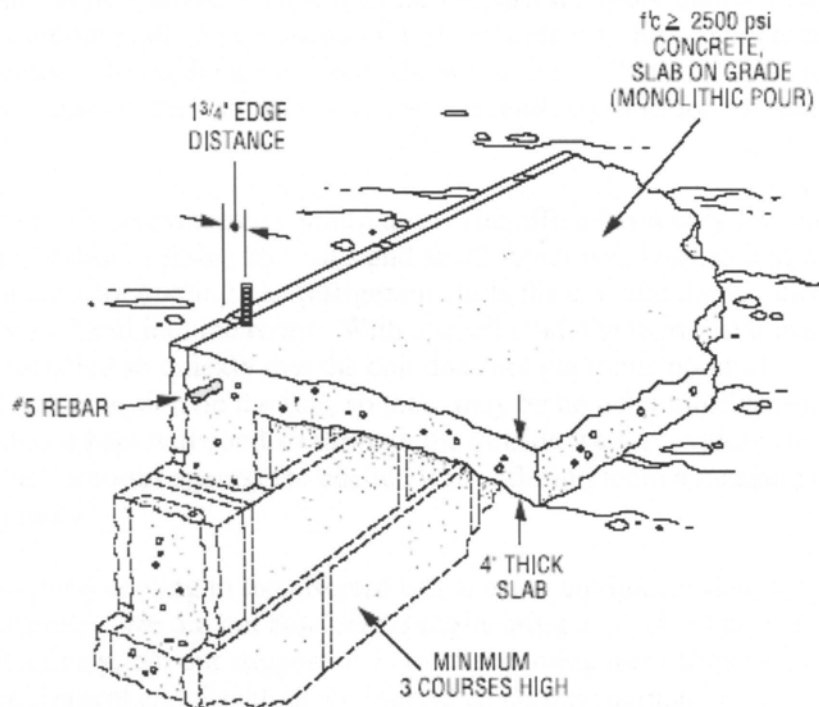


Figure 3: Showing the use of step blocks at the top of the stem wall. A step block has one face that is continuous (at the outside) and another face that is cut to provide a ledge that can be integrated with the slab. Note that in this case, the cores are grouted full, so water cannot collect in the cores. Also, in this drawing, are there openings for water in the cores to affect the wall framing above (not shown).

Courthouse Conditions

There were complaints of mold growing on law books in one of the offices in the courthouse. The two principal sources for this condition are site drainage and the cooling equipment.

Site drainage

The gutters for the building are rather small. The downspouts discharge ineffectively into tiles. The moat between the building and the walkway fills with water after a rain, as it did at the time of our inspection. This makes for a wet slab, and carpeting on a wet slab is never desirable.

Cooling Equipment

The courthouse makes use of cooling equipment. Previous complaints of mold or discoloration near the diffusers have been addressed with insulation at the backs of the diffusers.

The present complaint was of mold growth on the spines of some of the lawbooks, notably, the books that were shelved against the interior partition more than the books shelved against the outdoor wall. Mold grows on wet surfaces, and for porous materials such as paper and leather, the colder a surface is, the wetter it is. This was evidence that the books, especially those on the partition wall, were excessively cold for the building humidity.

The problem appears to be an oversized cooling unit. The office has a very low cooling load, especially with lawbooks lining the walls and small windows. During summer, when the thermostat calls for cooling, the refrigerant chills the coil and the fan blows chilled air across the coil and into the room. With a small load, the thermostat is satisfied quickly. It may be satisfied so quickly that the coil does not get to the point of developing running condensation on the fins, so there may be no dehumidification. During summer, outdoor heat will conduct through the outside wall, providing some slight warming to the lawbooks against the outside wall, offering them a measure of relative safety from mold.

We recommend providing cooling to the affected office using equipment that has some dehumidification capacity. We did not conduct an engineering analysis of how the loads can be met most effectively, but our suggestion is to start cooling this office using only the main building equipment and disabling the individual cooling equipment.

Other Issues

All bathroom exhaust fans connect to the same switch as the lights. This is a good practice that guarantees that the fan will be used every time the lights are turned on. The only improvement that can be suggested regarding this detail is to use a fan delay timer

instead of a single-pole on/off switch. The fan delay timer is a two function switch that is typically wired to a fan and a light. When the switch is turned-on, both the light and exhaust fan are turned-on. When the switch is turned-off, the light is turned-off but the fan continues to operate for an extended period of time. The extended period of time can be adjusted from 1 to 60 minutes. Fan delay timers are about \$40. (Available from Energy Federation Incorporated, www.efi.org , Fan/Light Time Delay Switch).

Mr. Jack Bekner, the Qualla Tribe electrician and our host, mentioned the reservation is using Panasonic ventilation fans in all their housing. Although much less expensive fans can be purchased, the Panasonic fans low some rating and high quality construction should translate into greater usage by occupants and less maintenance calls. Bath ventilation is very important to help keep bathroom humidity levels at a minimum to prevent mold problems. Properly venting these units to the exterior is also important.

Mr. Bekner also mentioned the reservation is installing range exhaust hoods that vent through the walls to the exterior. This is particularly important in homes that have gas ranges since one of the byproducts of the combustion of gas is water.

Most of the units had popcorn finish on the ceilings. Once mold establishes itself in popcorn finish, it is virtually impossible to clean. We recommend against the use of popcorn ceiling finishes, especially in bathrooms. A smooth finish is easier to clean, wipe-down and maintain by building occupants.

Take these several issues into consideration when placing heat pumps in attics:

- A heat pump will unquestionably complicate servicing the unit.
- A heat pump will reduce its efficiency.
- A heat pump will complicate replacing the unit.
- A heat pump might require a new access cut into the ceiling to remove and replace the unit.

Summary

The reservation is doing an outstanding job at addressing water management around its housing units. Building in hill country is difficult because every site usually has drainage problems. Although some of the units had drainage problems, it was obvious that there had been substantial efforts at creating swales and French drains to capture and divert water away from buildings. The reservation should be commended for their efforts to address these significant challenges.

The various members of the housing and building staff that we met appear to be dedicated and skilled. Their questions were intelligent and they know their building stock very well. We hope that we were able to assist them in the important job they have. The tribe should take pride in having people of this caliber entrusted with their buildings.

- ⁱ Penny, D.G. *Carbon Monoxide*, CRC Press: New York, 1996
- ⁱⁱ World Health Organization, *Environmental Health Criteria 213: Carbon Monoxide*, 2nd ed. WHO, Finland, 1999
- ⁱⁱⁱ Cobb, N.; Etzel, R.A.; Unintentional CO-related Deaths in the United States 1979 through 1988, *J. Am. Med. Assoc.* 1991, 266, 659-663.
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- ^v Myers, R.A.M.; DeFazio, A.; Kelly, M.P.; Chronic CO Exposure: A Clinical Syndrome Detected by Neuropsychological Tests; *J. Clin. Pathology* 1998, 54, 555-567.
- ^{vi} Institute for Environmental Health, *IEH Assessment on Indoor Air Quality in the Home (2): Carbon Monoxide*, Page Bros. Norwich, 1998
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- ^{viii} Chauhan, A.J.; Krishna, M.T.; Frew, A.J.; Holgate, S.T.; Exposure to Nitrogen Dioxide and Respiratory Disease Risk. *Rev. Environ. Health*, 1998, 13, 73-90
- ^{ix} Avol, E.L.; Linn, W.S.; Peng, R.C.; et al. Experimental Exposures of Young Asthmatic Volunteers to 0.3 ppm Nitrogen Dioxide and to Ambient Air Pollution. *Toxicol. Ind. Health*, 1989, 5, 1025-1034
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- ^{xiii} Pilotto, L.S., M. Nitschke, B.J. Smith, D. Pisaniello, R.E. Ruffin, H.J. McElroy, J. Martin and J.E. Hiller.; Randomized controlled trial of unflued gas heater replacement on respiratory health of asthmatic schoolchildren. *International Journal of Epidemiology*, 2004, Volume 33, Number 1, pp. 208-211. <http://ije.oupjournals.org/cgi/content/full/33/1/208>

1	2	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Inspection Number	Address	Building Age	Occupancy	Foundation Type	Model and Framing Type	Heat Type	Site Drainage Problems	Gutter System Problems	Leaks from Exterior	Wet Basement or Crawl Space	Plumbing Problems	Bathroom Problems	Exterior wall/ceiling Problems	Attic Problems	Visible Mold (Column #)
1.1	Courthouse	Varies with location	NA	Slab on grade	Ranch	Propane Furnace	Yes	Gutter Discharge questions	Maybe at Flashing	NA	No	No	No	No	-
1.2	Cucumber Road	New	Vacant	Slab on grade	Ranch	Heat Pump	To be determined	No Gutters Yet	No	NA	No	No	No	No	8
1.3	109 Tooni Branch	Unknown	Unknown	Slab on grade	Ranch	Unknown	Yes	Gutter Discharge questions	Unknown	NA	Unknown	Unknown	Yes	Unknown	-
2.1	110 Mary Jackson Road	Unknown	2 Adults 1 Child	Slab on grade	Ranch	Unvented gas Heater	Yes	Gutter Discharge questions	No	NA	No	Yes	Yes	Yes	14,15
2.2	88 Leebird Road	~15 Years	2 Adults 2 Children	Slab on grade	Ranch	Wood Stove	Yes	Gutter Discharge questions	No	NA	No	Yes	No	Unknown	14
2.3	Unknown	New	Vacant	Slab on grade	Ranch	Elec. Heat Pump	To be determined	No Gutters Yet	No	NA	No	No	No	No	-
2.4	Smith Road	Unknown	2 Adults	Slab on grade	Ranch	Propane Furnace	No	Gutter Discharge questions	No	NA	No	Former only	No	Unknown	
2.5	1045 Adams creek Road	13 years	2 Adults 2 Children	Slab on grade	Ranch	Unvented gas Heater	Yes	Gutter Discharge questions	No	NA	No	Yes	No	Unknown	14, 15
2.6	323 Kate Lambert Road	25 Years	Vacant	Crawl Space	Two Story	Propane Furnace	Yes	Gutter Discharge questions	Yes	Yes	No	Bathroom Guttered	Due to roof leak	Unknown	15

Inspection Number: 1-1
Address: Courthouse
Foundation: Slab-on-Grade
Construction: Furred-out block wall
Heat Type: Gas fired Forced air
Age: Varies with location



Figure 1: Courthouse

Mold and Moisture

Conditions:

The supply air diffusers, books and records in the storage closets and the library have had mold problems. Investigators suspect that rainwater management problems and the over-sized mechanical systems were the primary contributors to this problem.



Figure 2: Very long gutter w/downspout at each end



Figure 3: Downspout discharge to underground perforated tile

Site Drainage and Rainwater Management: The building had undersized gutters for the surface area drained (Figure 2). The downspouts emptied into a perforated drain tile disappearing into the ground with no evidence of where it discharges (Figure 3). The site was flat and the building was surrounded by a sidewalk which prevented the water next to the building from draining (Figure 4).



Figure 4: Sidewalk impedes drainage

Foundation Conditions: A footing with a block stem-wall supported the wall system and perimeter of the slab-on-grade floor system.

Exterior Conditions: The exterior of the building was in good condition, except for questionable flashing details on the sidewalls of the entry portals (Figure 5), and mildew growth on the siding near grade.



Figure 5: Questionable flashing detail

Interior Conditions: The interior was in good condition but only because of a thorough cleanup of mold. Air supply diffusers have in the past been covered with mold (Figure 6) as have court records and legal reference books.

Conditioning System: The building had multiple air-handling units located above the drop-in ceiling tiles.

Occupant Notes: Some occupants of this building have had adverse reactions to interior conditions.



Figure 6: Past diffuser problems

Discussion/Recommendations:

Resolution of the mold problem should first focus on two areas:

1. Rainwater management
 - This large building had undersized gutters for the amount of surface area to be drained. Replace the existing gutters with gutters having larger cross sections.
 - Address the drainage of the gutter system. Currently the downspouts drain into a perforated tile that disappears into the ground with no evidence of where it drains to. Rainwater may be carried by conduit tile under the sidewalk and parking lot to the stream at the rear of the building.
 - The sidewalks adjacent to the building function as a dam and trap water next to the foundation. Our Qualla hosts mentioned that at times the area between the sidewalk and the building was a big puddle. Bury drainage tile in this area to drain toward the stream or cut a space in the sidewalk to allow the water to escape.
 - Poor rainwater management contributes to the high humidity in the building. Water saturates the foundation stem-wall block and fills the cores with water. The water moves up into the wall, some which eventually finds its way into the building. The gravel base beneath the slab is likely to be wet and some of this moisture will also find its way into the building. Proper rainwater management is an important first step toward resolving the high inside humidity levels.
2. Mechanical System Issues:
 - Two areas with a particular mold problem were the judge's office (approx. 180 square feet), and the adjacent library (approx. 120 square feet). Books in the library had mold growing on them and dehumidifiers were used year-round to try

to control humidity. There was a single supply air register in the library and a supply register and return air grill in the judge's office (Figure 7).



Figure 7: Supply and return outlets

- Both of these rooms were served by an air-handler above the hallway ceiling. Investigators suspect that the mechanical system that serves these rooms is oversized and only provides sensible cooling and little or no dehumidification. In this case, bigger is not better. By just performing cooling, the air gets chilled which in turn increases its relative humidity.
- The office and library are not large areas and do not require a large amount of cooling capacity. One simple solution would be to abandon the existing system that serves these areas and tie the ductwork into one of the other mechanical systems proximate to this area (assuming the existing system has reserve capacity). This strategy may actually improve the dehumidification provided by the system since it would be taking on a greater load and would cycle longer. Longer cycling periods for cooling systems are desirable because greater dehumidification will be achieved.
- An alternate solution would be to lower the speed of the air passing over the cooling coil so that the moist air is in contact longer with the cooling coil and more moisture is extracted from the air. This strategy however runs the risk of ice buildup on the cooling coil and reduced “throw” of the air from the supply diffuser. It would also impact the heating mode of the system.
- The single supply register in the library is a problem if the door to the library is closed because the door does not have a grill to allow air out of the room, nor is it undercut. As long as the door is left open air can flow through the judge's office back to the return air grill. The configuration of supply and return grills is not conducive to good air distribution throughout the library.
- In the judge's office, co-locating the supply air register and return air grill high on the same wall is not a particularly desirable layout to achieve good air distribution throughout the room (Figure 7). The possibility exists that air is short-circuiting from the supply diffuser to the return air grill without properly mixing with room air. This can contribute to stagnant pockets of air in the room that have high humidity and contribute to the mold problem.
- The mold on the diffusers should not reappear if the humidity levels are reduced to a reasonable level. Insulating the top-side of the diffusers is a good idea, however if the humidity is not reduced, the mold will reappear during the next cooling season.

3. Other recommendations:

- The flashing on the sides of the entry portals, where the metal roofing meets the walls that project above the roofing, appears improperly installed (Figure 5). Check, and if a problem, resolve this issue.
- Until the rainwater management problems and mechanical issues are addressed, use of dehumidifiers is encouraged. Dehumidifiers can serve an important function in keeping interior humidity at a level below that needed for mold to grow.
- The following three websites provide information on how to properly size a gutter system. And the following article is from the first website.

<http://www.taunton.com/finehomebuilding/pages/h00046.asp>

http://www.copper.org/applications/architecture/arch_dhb/gutters_downspouts/gutter_calculation.html

<http://www.chrisind.com/architect.htm>

Following is an article that was published in *Fine Homebuilding* #125.

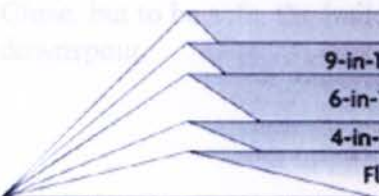
Sizing Gutter Systems

A Three-step Approach Helps You Calculate the Best Size for Your House

by Andy Engel

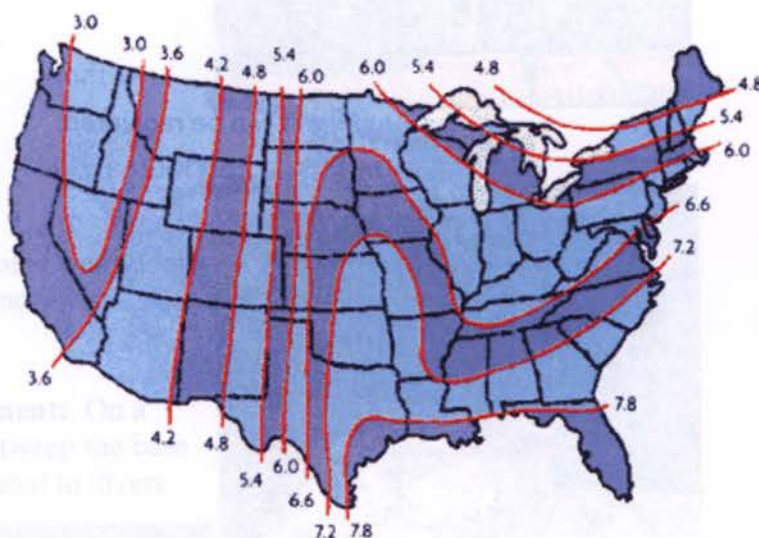
Gutters are essential to the longevity of most homes. Without gutters and downspouts leading rainwater away from the home, foundations become feedlots for mold that can sicken your family and rot your home. Once you've settled on a material, and a profile, you will need to pick a size. This procedure for sizing your gutter system is based on roof size, your area's likely rainfall intensity, gutter volume and downspout size and frequency.

1. Calculate your roof's watershed area -- A roof's watershed area is not obvious. Maximum rainfall is likely wind driven, so steep roofs may collect more water than flat roofs. To figure a roof's watershed area, multiply its surface area by the appropriate factor on the table.



Roof pitch	Factor
12-in-12	1.3
9-in-12 to 11-in-12	1.2
6-in-12 to 8-in-12	1.1
4-in-12 to 5-in-12	1.05
Flat to 3-in-12	1

2. Find the maximum likely rainfall intensity -- Residential gutters are often planned to handle the most intense five-minute burst of rain, measured in inches per hour, that's likely to occur in a ten-year period. Find yours on the map.


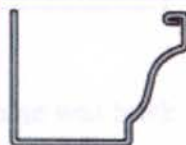


3. Determine the gutter needed to drain your watershed -- Divide your favored gutter's 1-in.-per-hour watershed (see the chart below) by the five-minute rainfall intensity (from the map above). This determines the maximum watershed level gutters can serve between downspouts. Pitch your gutters by 1/8 in. per ft., and you can multiply the watershed by 1.4.

Each square inch of downspout cross section can drain 100 sq. ft. of watershed. So a 2-in. by 3-in. spout drains up to 600 sq. ft., and a 3-in. by 4-in. spout drains 1,200 sq. ft.

Going from one downspout to two downspouts doubles the watershed that one section of guttering can drain.

Watershed drained by gutters at 1 in. rain per hour

	5-in. half-round:	2500 sq. ft.
	6 in. half-round:	3840 sq. ft.
	5 in. K-style:	5520 sq. ft.
	6-in. K-style:	7960 sq. ft.

Sample home -- An 8-in-12 pitch shed roof in Washington D. C. is 40 ft. wide, and its rafter length is 20 ft. The roof's area is 800 sq. ft. The pitch factor for an 8-in-12 pitch roof is 1.1; when multiplied by 800 sq. ft., a watershed of 880 sq. ft. is achieved. The theoretical 5,520-sq. ft. watershed drained by a 5-in. K-style gutter, divided by Washington's 6.6-in.-per-hr. rainfall intensity, shows a maximum watershed of 836 sq. ft. Close, but to be safe, the builder should pitch the gutter, use a larger gutter or add another downspout.

Inspection Number: 1-2
Address: Cucumber Road
Model Type: Ranch
Foundation: Slab-on-Grade
Construction: 2 x 4 Wood Frame
Heat Type: Heat Pump
Bedrooms: 3
Occupancy: vacant
Age: New

Mold and Moisture Conditions: This home was under construction and almost completed. No mold was present.

Site Drainage and Rainwater Management: On a hillside near the back of the home and between the base of the hill and the home, a swale was created to divert water away from the home (Figure 2). No gutter system was present, but one was to be installed.

Foundation Conditions: A footing with a block stem-wall supported the wall system and perimeter of the slab-on-grade floor system.



Figure 3: Recirculating range hood

Exterior Conditions: The exterior of the home was brick with vinyl siding on the gable ends of the home.

Bathroom: The bathrooms were nicely appointed and the bath fan connected to the same switch as the bath lights. Low sone Broan fans vented to the exterior through insulated ducts.

Kitchen: The range had a recirculating range hood (Figure 3).

Interior Conditions: This newly constructed home was in excellent condition.

Attic: The attic hatch was uninsulated (Figure 4). A gap between some of the batts of



Figure 1: Cucumber Road



Figure 2: Drainage swale at rear of home; vinyl siding on gable end of home



Figure 4: Uninsulated attic hatch

insulation exposed the top side of the drywall ceiling (Figure 5).

Conditioning System: The home was heated and air conditioned by a York Diamond 90 high-efficiency furnace. The air distribution system was in the attic with a central return grill in the living room wall. A gap was between the supply duct going through the ceiling and the drywall (Figure 6).

Occupant Notes: This new home was vacant.

Discussion/Recommendations:

Suggestions improvements for this well-designed home include:

1. Seal the gap between the duct and the drywall above the air-handler (Figure 6). Small gaps such as this can eventually result in problems. During the cooling season the area surrounding the air-handler is more than likely the coolest area in the home. This area can also become depressurized when the system is on when warm moist air from the attic can be drawn into the mechanical room closet. The warm moist air can then condense on the cool surfaces and eventually lead to mold problems.
2. Eliminate all gaps between batts of attic insulation, which can become a problem during the cooling season. The drywall ceiling can become cool (especially close to the air supply registers) and warm moist air in the ventilated attic can condense on the top-side of the drywall ceiling and result in mold.
3. Glue two inches of rigid insulation to the top-side of the attic hatch. During winter months, warm moist interior air can condense on the underside of the cold uninsulated attic hatch, and during the summer months warm moist air can condense on the top of the cool attic hatch.
4. Replace the recirculating range hood with one venting to the exterior, especially if a gas range is installed.
5. With no return-air ductwork present, air must escape beneath the bedroom doors into the hallway, so ensure that floor finishes do not constrict this flow of air.



Figure 5: Gaps between attic insulation



Figure 6: Air leak around duct to attic

Inspection Number: 1-3
Address: 109 Tooni Branch
Model Type: Ranch
Foundation: Slab-on-Grade
Construction: 2 x 4 Wood Frame
Heat Type: Unknown
Bedrooms: Unknown
Occupancy: Unknown – not present
Age: Unknown

Mold and Moisture Conditions: No one was home during our visit, so the interior of the home was not inspected. Mold conditions were unknown.

Site Drainage and Rainwater Management: A hillside on the north side drained toward the west (Figure 1). The home did have a gutter system.

Foundation Conditions: A footing with a block stem-wall supported the wall system and perimeter of the slab-on-grade floor system.

Exterior Conditions: The vinyl siding on the side of the home facing the hillside was exceptionally wavy (Figure 2). The siding was firmly attached to the substrate indicating that the substrate caused the buckling to occur.

Interior Conditions: The interior was not inspected.

Discussion/Recommendations:

The wavy siding and substrate indicate a moisture problem. One possible source for the moisture was the hillside that drained toward the house. Water saturated the ground on this side of the building and filled the block cores of the stem-wall foundation. Water in the cores evaporated and found paths around the bottom plate and migrated up into the wall. As the OSB sheathing absorbed moisture, it swelled. Installation of a French drain between the base of the hill and the home to drain to the west may eliminate any future water problems, but the OSB will not return to a planar state.



Figure 1: 109 Tooni Branch



Figure 2: Wavy siding on back of home

Inspection Number: 2 -1
Address: 110 Mary Jackson Rd
Model Type: Ranch
Foundation: Slab-on-Grade
Construction: 2 x 4 Wood Frame
Heat Type: Unvented gas heater
Bedrooms: 3
Occupancy: 2 Adults, one child
Age: Unknown



Figure 1: 110 Mary Jackson Road

Mold and Moisture Conditions: Mold was found at the exterior wall to ceiling junction in the living room (Figure 2), above the bathroom shower (Figure 3) and the bedroom ceiling junctures (Figure 4). Mold was also at the base of an exterior wall in the bedroom (Figure 5) and on the roof sheathing above the bathroom (Figure 6).

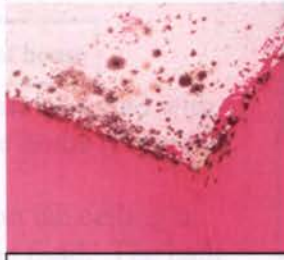


Figure 2: Mold on living room ceiling



Figure 3: Mold on ceiling above shower

Site Drainage and Rainwater Management: A swale between the hillside near the rear of the home and the home kept water from draining toward the home. Water was standing on the ground at the high-end of the swale (Figure 7). The home had a metal gutter system emptying into a perforated drain tile at the corners of the home. The outlet for the drain tile was not evident.



Figure 4: Mold at the wall to ceiling junction in the bedroom

Foundation Conditions: A footing with a block stem-wall supported the wall system and perimeter of the slab-on-grade floor system.



Figure 5: Mold in corner at the base of wall in the bedroom



Figure 6: Mold on the roof sheathing



Figure 7: Standing water next to house



Figure 8: Wavy siding on back of house

Exterior Conditions: The exterior of the home was clad with vinyl siding, which was wavy at the rear of the home (Figure 8).

Bathroom: The bathroom had mold growth on the ceiling in two areas, one above the shower and one in the field. The bath fan and light were on the same single-pole switch. The fan was barely capable of holding a sheet of toilet paper to the grill indicating that the fan was not moving much air. The toilet was not tight to the slab and there was condensation on the toilet tank.

Kitchen: The home had a propane range and recirculating range hood (Figure 9).

Interior Conditions: The home was well kept and there was not an abundance of clutter.

Attic: The attic hatch was uninsulated. There was no evidence of a bath fan duct. The attic was vented with soffit and ridge vents and ventilation baffles were evident along the perimeter of the attic. The ceiling of the home appeared to be well insulated with approximately 8" of fiberglass batt insulation.

Conditioning System: The home was heated by a free-standing unvented gas heater located in an outside corner of the living room (Figure 10). There was no cooling or air distribution system.

Occupant Notes: Two adults and one child lived in the home. One had bronchitis and another was diabetic.



Figure 9: Gas range with recirculating range hood



Figure 10: Primary heat source: unvented gas heater

Discussion/Recommendations:

1. Several sources of moisture contributing to the mold problem include:

- a. Water from the exterior saturating the foundation, particularly at the rear of the building, and finding its way into the home (Figure 11)
- b. Moisture from the unvented gas heater
- c. Moisture from the unvented gas range
- d. Bathroom moisture



Figure 11: Standing water in depression next to foundation. Note wet block.

2. The standing water in the yard may be resolved with improved grading and drainage. The swale at the rear of the home was not draining the water away from the building fast enough, so the water near the building saturated the foundation and some of this water will find its way into the building's walls. It had already done so at the back of the home as evidenced by the wavy siding.
3. One solution to drain the swale would be to cut a French drain into the low point of the swale, continuing it around the side of the home, and run it to daylight.
4. The wavy siding and substrate indicate a moisture problem at the back of the home. The probable source for the moisture causing this problem is the hillside that drained toward the home. Water saturated the ground on this side of the building and filled the block cores of the stem-wall foundation. Water in the cores evaporated and found paths around the bottom plate and migrated up into the wall. As the OSB sheathing absorbed moisture, it swelled. The French drain previously mentioned should help. However, although this may eliminate any future water problems, the OSB will not return to a planar state.
5. A substantial contributor to the moisture problem was the unvented gas heater. Installation of a furnace or heat pump would not only eliminate this source of moisture (and pollutants), but would also provide better heat distribution throughout the home.
6. Vent the range hood to the exterior so moisture from cooking is eliminated. Since the range is on an exterior wall, this would be a simple process.
7. Duct the bathroom fan through an insulated duct to the exterior with as short a duct as possible.
8. Glue two inches of rigid insulation to the top-side of the attic hatch. During winter month's warm moist interior air can condense on the underside of the cold uninsulated attic hatch, and during the summer months warm moist air can condense on the top of the cool attic hatch.

9. Ceilings in the home have a “popcorn” finish. Once mold grows on these finishes, they are impossible to clean. Where moldy, the finish needs to be scraped off and removed before the area can be properly cleaned with soap and water. “Popcorn” ceiling finishes are not recommended, particularly in bathrooms.
10. The mold at the wall to ceiling junction indicates colder temperatures at these areas than the rest of the room. Check the insulation in the attic above these areas making sure it is properly installed and add more if necessary. Poor heat distribution and high humidity, both caused by the type of heating system installed, contribute to this problem.
11. Mold on ceiling surfaces in the field usually indicates a gap in the ceiling insulation. Gaps in insulation allow lower surface temperatures which results in higher humidity at these areas and ultimately mold.
12. The slight mold on the roof sheathing should become dormant if the bath fan is vented properly.

Inspection Number: 2 -2
Address: 88 Leebird Road
Model Type: Ranch
Foundation: Slab-on-Grade
Construction: 2 x 4 Wood Frame
Heat Type: Wood Stove
Bedrooms: 3
Occupancy: 2 Adults, 2 Children
Age: ~ 15 Years

Mold and Moisture Conditions: Mold was present in the bathroom around and above the tub area (Figures 2 & 3). Other areas that had been moldy in the past were window sills and closets, which had recently been cleaned.

Site Drainage and Rainwater Management: A swale between the hillside and home was designed to keep water from draining toward the home. There was standing water on the ground at the front of the home (Figure 4). The home had a metal gutter system that emptied into a perforated drain tile at the corners of the building. The outlet for the drain tile was not evident. There were several depressions next to the foundation (Figure 5) and the sidewalk on the end of the home acted as a dam (Figure 6).



Figure 1: 88 Leebird Road



Figure 2: Deterioration of wall above tub surround



Figure 3: Mold on ceiling above tub



Figure 4: Standing water in yard in front of house



Figure 5: Depressions next to foundation



Figure 6: Sidewalk acts as a dam

Foundation Conditions: A footing with a block stem-wall supports the wall system and perimeter of the slab-on-grade floor system.

Exterior Conditions: The exterior of the home was clad with brick and vinyl siding on the gable ends. The vinyl siding was damaged on one end of the building.

Bathroom: The bathroom had mold growth on the ceiling and above the tub surround. The vinyl tile around the base of the toilet was missing (Figure 7). The bath fan and light were on the same single-pole switch, but the fan did not appear to be exhausting much air.



Figure 7: Missing floor tile around toilet

Kitchen: The home had an electric range and range hood that vented to the exterior.

Interior Conditions: The home was well kept and there was not an abundance of clutter. The lady of the home stated mold and damp floors were a problem in the past. However, last summer they used two window air conditioners to dehumidify the air and that worked well. There was a lot less mold and the floors stayed dry.

Attic: The attic was not accessed.

Conditioning System: The home was heated by a free-standing wood stove located in the living room. There was no central cooling or air distribution system. The home was slated to have a heat-pump installed.

Occupant Notes: Two adults and two children lived in the home.

Discussion/Recommendations:

1. The primary sources of moisture contributing to the mold problem include:
 - a. Water from the exterior saturated the foundation and slab and would find its way into the home
 - b. Bathroom moisture
 - c. Humidity from ambient air
2. A swale at the rear of the home kept the area behind the home drained. However, there was standing water in the front yard. As the water near the building saturated the foundation, some of this water found its way into the building's walls and migrated through the slab. All the downspout drains should be run to daylight through rigid and unperforated drain tile.

3. The sidewalks next to the building act as dams and trap moisture next to the foundation. These areas should be drained with a drain tile.
4. The depressions next to the foundation should be filled, compacted and seeded. Currently these depressions act as funnels channeling water towards the foundation.
5. Wall outlets in the gable end of the building indicate that the bath fans are vented to the exterior. The attic should be checked to make sure the fans are ducted through insulated ducts.
6. One occupant mentioned mold had formed at the wall to ceiling junction in the bedrooms but that she had cleaned it up. One significant contributor to this problem is that the only source of heat, the wood stove, is at one end of the building. The bedrooms, at the other end of the building stay much cooler since there is no heat distribution system. Installation of the heat pump should help minimize occurrence of mold at wall to ceiling junctions since heat distribution will be far more even than with the wood stove.
7. Replace the deteriorating vinyl covered fiberboard above the bathtub surround and the vinyl tile around the toilet with a moisture resistant material.
8. The owner complained of mold on her wood window sashes. The windows were slated to be replaced with Low-e insulated vinyl units which should reduce condensation problems and be easier to clean.
9. The homeowners had a dehumidifier in the washer and dryer closet but it was at the opposite end of the home from the bedrooms. More than likely, the dehumidifier will not be needed once the heat-pump is installed.

Inspection Number: 2 -3
Address: Unknown address
Model Type: Ranch
Foundation: Slab-on-Grade
Construction: 2 x 4 Wood Frame
Heat Type: Heat pump
Bedrooms: 3
Occupancy: Vacant
Age: New



Figure 1: Unknown address

Mold and Moisture Conditions: This home under construction was almost completed. No mold was present.

Site Drainage and Rainwater Management: A hillside was near the rear of the home (Figure 2). A swale between the hillside and home kept water from draining toward the home. The home did not yet have a gutter system, nor was there any evidence of drain tile for the downspouts to empty into at the corners of the building.

Foundation Conditions: A footing with a block stem-wall supports the wall system and perimeter of the slab-on-grade floor system.

Exterior Conditions: The exterior of the home was clad with vinyl siding.



Figure 2: Hill at rear of home

Bathroom: The bathroom was new and unused.

Kitchen: The range hood was going to be a recirculating unit.

Interior Conditions: The interior was all new.

Attic: The attic was not accessed.

Conditioning System: A heat pump was installed in the attic.

Occupant Notes: The home was vacant.

Discussion/Recommendations:

1. Locating the heat-pump in the attic may cause servicing problems.
2. Vent the range hood to the exterior through the back wall.

3. Establish drainage from downspouts through rigid unperforated underground conduits that drain to daylight on the hillside in front of the home.
4. Give special attention to the finish grading at the rear of the home. Effective drainage of this area is important to keep the foundation dry so that it does not lead to wavy siding as seen on other homes.

Figure 1: South front

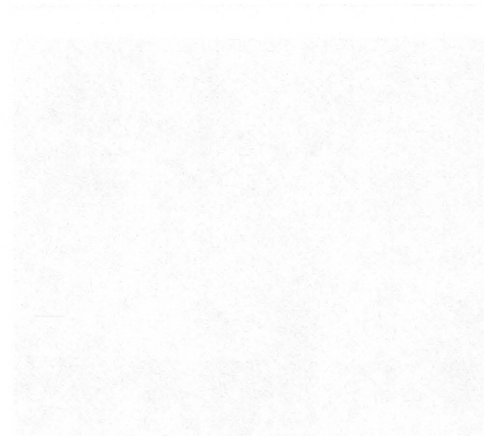


Figure 2: Steeply rising back slope



Figure 3: North elevation



Figure 4: Exterior dryer vent location



Inspection Number: 2 -4
Address: Smith Road
Model Type: Ranch
Foundation: Piers w/skirting
Construction: 2 x 4 Wood Frame
Heat Type: Gas Furnace
Bedrooms: 3
Occupancy: 2 Adults
Age: Unknown



Figure 1: Smith Road

Mold and Moisture Conditions: The occupant's mother stated mold was present in the bathroom above the tub area. Cleaning of the mold caused the popcorn finish to come off the ceiling (Figures 2). The only other area that had had mold was in the living room at the ceiling marriage joint of the modular units. Again, the mold was not present because the owner had cleaned the area.



Figure 2: Missing ceiling finish where mold had been cleaned up

Site Drainage and Rainwater Management: A hillside was near the rear of the home. Site drainage was not as much of an issue with this home because it was a modular home approximately three feet off of the ground. The building was therefore significantly decoupled from ground conditions. Skirting surrounded the base of the building and a weed whacker had violated the skirting enough to provide surround ventilation. The home had a metal gutter system that emptied into a perforated drain tile at the corners of the building. The outlet for the drain tile was not evident.

Foundation Conditions: The skirting was not removed to look under the building, but the foundation probably consists of piers.

Exterior Conditions: The home exterior was clad with vinyl siding.

Bathroom: The bathroom had had mold growth on the ceiling above the tub before it was cleaned up (Figure 2). The exhaust fan worked very well.

Kitchen: The home's electric range hood that vented to the exterior.

Interior Conditions: The home was well kept and there was not an abundance of clutter. The dryer vent exhausted to an unclear location (Figure 4).



Figure 3: Dirty return-air grill



Figure 4: Unclear dryer vent location.

Attic: The attic on this modular unit was not accessible.

Conditioning System: The home was heated by a gas furnace located in a living room closet.

Occupant Notes: Two adults lived in this home.

Discussion/Recommendations:

1. Mold is not usually found in a bathroom where the fan works as well as this one did. Insulation missing above the moldy spots probably caused them to be colder than the surrounding areas that did not have mold. This area could be examined from the exterior if the soffit were removed. The only other way to inspect this area would be to remove the drywall and inspect the area from below. If the drywall is removed, install a sheet of rigid insulation before reinstalling drywall. The insulation will provide a thermal break between the drywall and the structure.
2. The mold on the marriage joint on the living room ceiling could be due to condensation or leakage from above. If the mold was in only one area, it would indicate a leak from above rather than condensation. On the exterior, on the back of the building, there was a roof vent at the approximate location of the moldy spot. Check the roof vent, flashing and surrounding shingles for leaks.
3. Clean the return air grill and change the furnace filter.

Inspection Number: 2 -5
Address: 1045 Adams Creek Road
Model Type: Ranch
Foundation: Slab-on-Grade
Construction: 2 x 4 Wood Frame
Heat Type: Unvented gas heater
Bedrooms: 3
Occupancy: 2 Adults, 2 Children
Age: 13 years

Mold and Moisture Conditions: Mold was found at the exterior wall to ceiling junction in the bedrooms (Figure 2), on the wood window sashes (Figure 3), and the bathroom ceiling (Figure 4).

Site Drainage and Rainwater Management: A hillside swale at the rear of the home between the hillside and house was designed to keep water from draining toward the home, but was high enough on the hillside to shed a significant amount of water toward the home (Figure 5). Water was standing on the ground near the home (Figure 6). The home had a metal gutter system that emptied into a perforated drain tile at the corners of the building. The outlet for the drain tile was not evident.

Foundation Conditions: A footing with a block stem-wall supported the wall system and perimeter of the slab-on-grade floor system.

Exterior Conditions: The exterior of the home is clad with a brick wainscot and vinyl siding above.

Bathroom: The bathroom had mold growth on the ceiling near the exhaust fan. The fan drew tissue paper tight to the grill indicating it was exhausting a substantial volume of air. The owner



Figure 2: Moldy bedroom ceiling juncture.

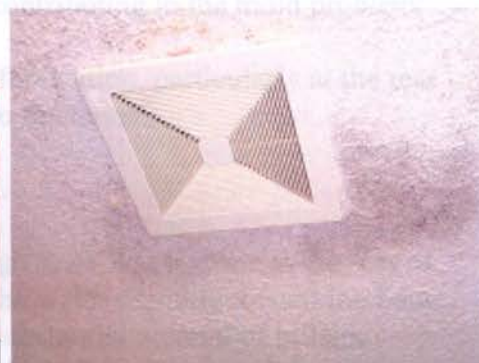


Figure 4: Moldy ceiling around bath fan



Figure 3: Moldy window sash



Figure 5: Grade toward house



Figure 6: Standing water in yard

said that there had been mold at the top of the tub surround where it met the wall. Repeated cleaning at this location had worn off the paper face of the drywall; however, during the inspection everything had been cleaned and repainted, so no mold was visible. Everything else in the bathroom appeared to be in good condition.

Kitchen: The home had an electric range and recirculating range hood.

Interior Conditions: The home was well kept and there was not an abundance of clutter. The owner stated that he had had mold problems in his closet, such as mold on his leather shoes and on the wood on the gun stock of his rifles, but through diligent cleaning had kept items relatively clean.

Attic: The attic was not inspected.

Conditioning System: The home was heated by a wall mounted unvented gas heater located on an outside wall of the living room at one end of the home (Figure 7). There was no cooling or air distribution system.

Occupant Notes: Two adults and two children lived in the home. One person had asthma problems and another adult smoked. Dogs also lived inside the home.

Discussion/Recommendations:

1. The home had two primary moisture sources contributing to the mold problem:
 - a. Water from the exterior saturating the foundation, particularly at the rear of the building, and finding its way into the home.
 - b. Moisture from the unvented gas heater.
2. There was standing water in the yard. Although there was a swale at the rear of the home, it was too far away to intercept all the water draining toward the home. Between the swale and the home there was a substantial amount of hillside draining toward the home. As the water near the building saturated the foundation, some of this water found its way into the building's walls.
3. Resolving the water drainage problem at the back of the home will require some effort, such as excavating next to the foundation, waterproofing the foundation wall, installing drain tile and rock adjacent to the foundation and draining the tile into an exterior sump that then pumps the water to the hillside at the front of the home. Drain the downspouts on the rear of the home into the sump to minimize the amount of water that must percolate through the ground at the rear of the home.
4. Another contributor to the exterior water problem is the driveway which is long and slopes toward the home. Install a linear trench to intercept this water at the

junction between the concrete pad next to the home and the asphalt driveway. While this is being done, dam the area on the high side of the drive at the concrete to asphalt junction to drain through the linear drain rather than rely on surface drainage around the back of the home. This would substantially reduce the amount of water funneled towards the rear of the home.

5. Another substantial contributor to the moisture problem is the unvented gas heater. Installation of a furnace or heat pump would not only eliminate this source of moisture (and pollutants), but would also provide better heat distribution throughout the home.
6. Vent the moisture from cooking to the exterior through a range hood vented to the exterior.
7. Ceilings in the home have a popcorn finish. Once mold grows on these finishes, they are impossible to clean. Where moldy, the finish needs to be scraped off and removed before the area can be properly cleaned with soap and water. Popcorn ceiling finishes are not recommended, particularly in bathrooms.
8. The mold at the wall to ceiling junction indicates colder temperatures at these areas than the rest of the room. Check the insulation in the attic above these areas making sure it is properly installed and add more if necessary. Poor heat distribution and high humidity, both caused by the type of heating system installed, contribute to this problem.
9. The occupant stated that family members had been getting sick and suspected that it was due to mold. Investigators identified other potential contributors to health problems: a) pets kept inside the home, b) smoking inside the home, and c) the unvented gas heater. The pets contribute pet dander to the interior environment which is known to trigger asthma attacks in certain individuals. The negative health effects of first and second hand smoke is well known, and the health effects of unvented gas heaters is still being researched, but anecdotal evidence suggests that the pollutants emitted by these units may be detrimental to occupants health. Mold may be a contributor to health problems, but other contributors to health problems may exacerbate or take precedence over the health effects of mold. The following suggestions may help improve occupants health:
 - a) Install a heating and cooling system and a duct system for distribution to eliminate the uneven heat distribution and probably eliminate winter condensation on cool interior surfaces.
 - b) Install a properly sized cooling system to reduce interior humidity during hot humid weather and the incidence of mold.
 - c) Install a central heating and cooling system to eliminate the pollutants and moisture emitted by the unvented gas heater.

- d) Keep pets out of living areas to eliminate pet dander and its potentially negative health effects.
- e) Smoke outside to minimize the negative effects of second-hand smoke.

Inspection Number: 2 - 6
Address: 323 Kate Lambert Road
Model Type: Two Story
Foundation: Crawl Space
Construction: 2 x 4 Wood Frame
Heat Type: Gas furnace
Bedrooms: 4
Occupancy: Vacant
Age: 25 years

Mold and Moisture Conditions: One obvious instance of mold in this home was above a window where the roof had leaked (Figure 2). Also a slight amount of mold was on the floor joists above the crawl space.

Site Drainage and Rainwater Management: A hillside was near the rear of the home. The ground around the home was soft and saturated with water. The home had a metal gutter system that emptied onto grade immediately adjacent to the foundation wall (Figure 3).

Foundation Conditions: The home was built on a crawl space with the vapor barrier discontinuous and much of the batt insulation falling down from between the floor joists (Figure 4). The floor of the crawl space was damp and very uneven (Figure 5). The floor joists had a slight amount of mold on them.

Exterior Conditions: The exterior of the home was clad with vinyl siding that was poorly



Figure 1: 323 Kate Lambert Road



Figure 2: Saturated Celotex sheathing next to window framing



Figure 3: Downspout discharge next to foundation wall



Figure 4: Insulation falling down from between floor joists



Figure 5: Crawl space with missing VB and fallen insulation. Note wet soil.

installed in some areas (Figure 6). The low slope roof over a one-story portion of the home had a leak that allowed water into the wall system (Figure 7). The consequence of the leak was saturated Celotex siding and mold (back to Figure 2).

Bathroom: The home was in the process of being rehabilitated for rewiring, therefore there was no bathroom to inspect.

Kitchen: The kitchen was being rehabilitated.

Interior Conditions: The interior was being rehabilitated.

Attic: The attic was not inspected.

Conditioning System: The home was primarily heated by a high efficiency gas furnace with a secondary vented gas heater.

Occupant Notes: This home was vacant.

Discussion/Recommendations:

1. The ground around the building was spongy and wet. This moisture was also evident on the floor of the crawl space where there was no vapor barrier.
2. Install a heavy vapor barrier (VB) over the floor of the crawl space after cleaning and leveling the crawl space floor. Seal the VB to the masonry block wall with mastic and a termination strip along its perimeter.
3. The fiberglass batt insulation between the floor joists is ineffective. Much of it has fallen down from between the floor joists, and the insulation that is still in place is compressed by the stiff wire stays that are intended to hold it in place. A more effective way to insulate the base of the building would be to include the crawl space in the thermal envelope by insulating the block walls with 2" thick rigid polystyrene insulation and getting rid of the batts between the joists. An alternative method of insulating the base of the building would be to mechanically fasten 2" thick rigid polystyrene insulation to the bottom of the joists.
4. The mold at the head of a window was due to a roof leak on a very low sloped roof. Rebuild the roof at a higher slope so that water does not sit on it. Remove



Figure 6: Poorly installed vinyl siding



Figure 7: Roof leak that allowed water into the wall

the moldy drywall during the gutting process. If the roof leak is eliminated, the problem should be resolved.

5. The discharge of downspouts next to the foundation wall is a problem. This water saturates the ground next to the building and some of it eventually finds its way into the crawl space. Connect these downspouts to an underground, unperforated conduit and conduct the water to the hillside at the front of the home.
6. This building has many different roof systems, several of which butt into walls. Properly flash the intersection of roofs to walls to keep water out of the wall systems.
7. The fastening of the back deck to the structure appears improper (Figure 8). If this junction is not flashed properly, water can get between the rim joist of the deck and the building and slowly rot structural framing members. Check and resolve during remodeling the moist areas inside the wall opposite the outside deck wall (Figure 9).



Figure 8: Improper deck to home junction



Figure 9: Deck on opposite side of wall